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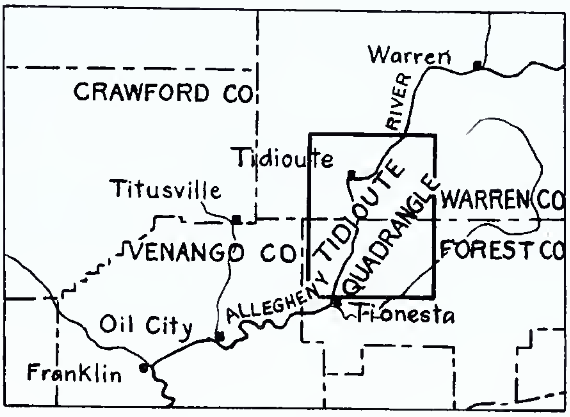
GEOLOGY OF THE OIL AND GAS FIELDS OF THE TIDIOUTE QUADRANGLE, PENNSYLVANIA

(Advance Report)

by

S. H. Cathcart, R. E. Sherrill and L. S. Matteson



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CONTENTS

Page

Introduction 1
Topography and drainage 2
Surface stratigraphy 2
    Pennsylvanian 2
        Pottsville formation 2
    Mississippian 2
        Shenango sandstone 3
        Corry sandstone 3
    Devonian 3
        Conewango formation 3
Surface structure 3
    Regional 3
    Local 4
The Oil and gas sands 4
    Venango oil sand group 4
        Isometric projection of Venango sands 4
    List of the oil and gas sands 5
        First sand 6
        "White" sand 6
        Second sand 7
            Extent, character and thickness 7
            Structure 7
            Production 8
        Salt sand 8
        Correlation of Second and Salt sands 9
        "Little Minister" stray 9
        Third sand 9
            Extent, character and thickness 9
            Structure 10
            Production 10
            Triumph Streak oil pool 10
            Fagundus oil pool 11
            Other Third sand pools 11
        Fourth sand 11
    Sands below the Venango oil sand group 12
        First Warren sand 12
        Second Warren sand 12
        Queen sand 12
        Clarendon sand 13
        Speechley sand 13
        Sands below the Speechley 14
Selected well records 14

ILLUSTRATIONS

Figure 1. Map showing production and surface structure.
2. Isometric projection of Venango oil sand group.
3. Map showing areas in which "White" sand occurs, either alone or as a part of the First sand, and the names by which it is know.
4. Map showing thickness of Second sand.
5. Map showing Second sand production and structure.
6. Map showing thickness of Third sand.
7. Map showing Third sand production and structure.
8. Map showing Queen sand production and structure and location of wells, the records of which are published in this report.

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INTRODUCTION

The Tidioute quadrangle is in northwestern Pennsylvania, and occupies a part of southern Warren and northwestern Forest counties. It covers about 224 square miles - 17.25 miles north and south 13 miles east and west.

This quadrangle and the Titusville and Oil City quadrangles adjoining it to the west and southwest, contain the oldest oil fields in petroleum history. In this part of Pennsylvania the oil industry had its birth and early development. Many formerly productive areas have been completely abandoned, leaving most of the oil in the sands. Some of these areas have been reclaimed through modern secondary recovory operations. Other areas known, or reasonably certain, to contain oil were never developed because the wells did not produce in sufficient quantities. Improvements in production methods may make these areas commercially productive. Except for the early work of Carll(1), and the various republications of his astute conclusions, very little geological information on this historically famous and potentially valuable oil region has been assembled. The purpose of this survey was to determine as minutely as possible the subsurface distribution, character, thickness, structure and content of the productive or potentially productive sand bodies. It was felt that, in addition to preserving the data still available, such survey might assist in the selection of areas for additional oil recovery, in the development of these areas, and possibly, in locating new shallow or deep pools.

The detailed survey was started in this quadrangle because in it lies the northeastern terminus of Venango oil sand production, and because several of tho sands producing to the southwest outcrop here.

Every available well record was collected, each well located on a 4 inch to 1 mile topographic map and the well elevations determined with an altimeter. Where possible, well samples of the sands were collected. Very little coring has been done in this quadrangle. The known producing limits of the sands were drawn on the maps and all available verbal information on the sands was assembled. About 2,500 well records were collected, of which 1,906 wells were located and the elevations determined. This work was done by S. H. Cathcart, assisted by L. S. Matteson and W. H. Gotwald during the field seasons of 1936 and 1937. The data were analyzed and the report written at the University of Pittsburgh by R. E. Sherrill and L. S. Matteson.

We regret that it is impossible to mention here each company and individual who aided in this survey. We especially desire, however, to express appreciation to the Clinger Oil and Gas Company for their time, records and active support, and to the National Petroleum Company, the United Natural Gas Company, Penn Rock Oil Company, and to Frank Dunbar, Bowman Proper, J. L. Morrison, E. Bowman, C. Geisen,

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1. Carll, John F., The geology of the oil regions: Pennsylvania Second Geological Survey, Report I 3, 1880.

J. Logan, O. Johnson and the many other leaseholders who cooperated to the fullest extent. Without the support and information supplied by the operators here the report could not have been completed.

TOPOGRAPHY AND DRAINAGE

This quadrangle lies wholly within the drainage basin of the Allegheny River, which traverses it from north to south in a narrow gorge-like valley. In a similar steep-sided valley Tionesta Creek flows across the southeastern part and enters the Allegheny River about one mile south of the quadrangle. The smaller streams occupy steep-walled valleys. The divides form an undulating plateau, mostly between 1,700 and 1,800 feet above sea level. The lowest point in the quadrangle is about 1,050 feet above sea level and the highest is about 1,930. Part of the area is farm land but most of it is wooded.

SURFACE STRATIGRAPHY

Approximately 1,000 feet of lower Pennsylvanian to Upper Devonian rook strata are exposed in the Tidioute quadrangle. As the primary purpose of this study was to determine the subsurface geologic conditions no detailed survey of these surface rocks was made.

Pennsylvanian

Pottsville formation: Pottsville strata constitute the upper 100 feet or more of the higher hills and dissected plateau. Coarse, gray quartz sandstones and conglomerates are particularly prominent in this part of the section, and by their resistance to erosion have maintained, especially in the western half of the quadrangle, the plateau character of the upland surface.

In the northern part of the quadrangle the Olean conglomerate constitutes the basal 20 to 45 feet of the Pottsville. According to Butts (1) the Olean thins out entirely between Tidioute and Tionesta. To the south the basal member of the Pottsville is the Connoquenessing sandstone, the Olean never having been deposited.

The Pottsville rocks rest unconformably on the Mississippian. This regional unconformity is a dominant feature of the stratigraphic column throughout western Pennsylvania. The rocks below the unconformity were tilted southward, probably folded slightly, and truncated by erosion before the Pottsville rocks were deposited. As a result of this unconformity, and of the irregularity of the Pottsville sandstones, no Pennsylvanian bed in this area is reliable for mapping the structure.

Mississippian

The top of the Mississippian is marked in this quadrangle by the unconformity at the base of the Pottsville sandstones. Considerable difference of opinion still exists as to the exact position of the bottom of the Mississippian here. On paleontologic and stratigraphic evidence Caster concluded that the Mississippian-Devonian contact lies at the base of the Knapp beds, and places this horizon in the Dennis Run section at Tidioute at a "Spirifer bed" 120 feet below the top of the Corry sandstone and 110 feet above the top of the First oil sand (2). If this lower limit, which is here tentatively accepted, is correct, there are 300 to 400 feet of Mississippian strata in the quadrangle. The Mississippian is thickest in the southern part of the area. It decreases in thickness northward owing to the erosion preceding Pottsville deposition and is about 325 feet thick at Tidioute. It consists predominantly of shale, some of which is quite sandy, and contains several sandstone members. Two of these sandstone members - the Shenango and the Corry - are particularly prominent and useful in mapping the surface structure.

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1. Butts, Charles, Pre-Pennsylvanian Stratigraphy: Topographic and Geologic Survey, Commonwealth of Pennsylvania, Report 1906-1908, p. 193.
2. Caster, Kenneth E., Stratigraphy and Paleontology of northwestern Pennsylvania: Bull. of Am. Paleo., vol. 21, no.71, 1934, pp. 105, 106 and 120.

Shenango sandstone: The Shenango is the highest sandstone member of the Mississippian here. It is a brown to yellow, thin-bedded sandstone 0 to 40 feet thick. Typically fairly fine grained, it is conglomeratic in some localities. It is absent in the northeasternmost part of the quadrangle owing to the unconformity at the base of the Pottsville. The interval between the base of the Shenango and the top of the Corry is fairly constant at about 145 feet throughout the quadrangle. The Shenango here is commonly called Mountain sand where noted in well records. The term Mountain sand is used very loosely, however, and may be applied to any of the sands above the First oil sand.

Corry sandstone: The Corry sandstone of northwestern Pennsylvania, named from its exposure in the Colegrove quarries south of Corry, is a threefold unit consisting of two sandstones separated by shale. The average total thickness is about 20 feet. This sandstone lies 145 feet below the Shenango sandstone and about 250 feet above the First oil sand. Lithologically it is the most characteristic unit in this region, and is the most usable in mapping the surface geology. The upper member of the Corry is a hard, dense, very fine-grained light gray sandstone. The medial shale is commonly light gray and sandy. The lower sandstone member is also a hard, uniform, fine-grained sandstone. It is relatively clayey and decidedly yellow. The Corry is generally considered to be correlative with the upper member, at least, of the threefold Berea formation of Ohio. Cathcart has suggested that the three Corry members are the equivalent of the three Berea members(1), and by field tracing, has determined that the lower Corry member probably is the equivalent of the upper Knapp. The Corry is commonly called Blue Monday, or less frequently Mountain sand, in the records of wells penetrating it.

Devonian.

Conewango formation: About 450 feet of strata below the top of the Corry sandstone are exposed in the Tidioute quadrangle. If the Mississippian-Devonian contact here lies about 120 feet below the top of the Corry, as is here tentatively accepted, the lower 330 feet of these exposed rocks are of uppermost Devonian age. These 330 feet of strata are the upper part of the Conewango formation, as defined by Butts(2). They are exposed in the lower part of the valley of the Allegheny River, the maximum exposed thickness being where this river enters the quadrangle. They consist of shales interbedded with flaggy and massive sandstones.

Three prominent sandstone members occur in the lower 150 to 200 feet of the exposed part of the Conewango. These are the First and Second oil sands and the Salt sand. These sandstones, with the intervening shale members, constitute the exposed upper part of the Venango Oil Group as defined by Carll.(3) The top of this group, marked by the top of the First oil sand, lies about 250 feet below the top of the Corry sandstone. Northeast of the Tidioute quadrangle, in the Bradford district and in Cattaraugus County, New York, the Venango Oil Group is represented by the red and greenish-gray shales, sandstones and conglomerates of the Cattaraugus formation.

The character, thickness, distribution and structure of these sands are discussed in more detail later in this report.

SURFACE STRUCTURE

Regional

Structurally, the Tidioute quadrangle is in the northwestern part of the Appalachian foreland. This foreland lies west and north of the closely folded and faulted Appalachian Mountains. It is a broad, gentle, spoon-shaped synclinorium, whose long axis extends in a northeasterly and southwesterly direction, and whose lowest part is in northwestern West Virginia.

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1. Cathcart, S.H., Structural and areal distribution of certain key beds in northwestern Pennsylvania; Bull. of Penna. Topo. and Geol. Survey, awaiting publication.
2. Butts, Charles, op. cit.
3. Carll, John F., op. cit.

The central and southeastern parts of this foreland synclinorium are characterized by a series of rather prominent northeast-trending anticlinal and synclinal folds. In the northern part of the foreland the folds have so diminished in magnitude and regularity that their detection and tracing can be accomplished only by determining elevations on selected "key" rock layers at many points over the area. The dominant structural feature of this part of the foreland, in which lies the Tidioute quadrangle, is a general southward inclination or regional dip.

Local

The surface structure map of the Tidioute quadrangle, Figure 1, shows the elevation above sea level of the top of the Corry sandstone by means of 25-foot contours. Because of the absence of abundant outcrops, or of well records in which this sandstone could be identified with certainty, this structure map is generalized.

The regional dip in this quadrangle, as can be seen from this map, is slightly west of south. The Corry sandstone descends 380 feet in a southerly direction in about 17.5 miles, or an average of about 22 feet per mile. The most prominent fold extends from Fagundus to a point about two miles east of Tidioute. It is here called the Fagundus anticline. A gentle west-plunging anticline overlying the eastern part of the Triumph Streak oil pool probably is a compaction fold over the thick Triumph sand lens. The syncline between the two anticlines mentioned above is so gentle and indistinct that the entire surface structure southwest of Tidioute presents the appearance of a single southwest-plunging anticline. In deeper sands this syncline becomes more prominent. There is a distinct west-plunging syncline about two miles north of the Triumph Streak.

Between Newtown and Kellettville, in the extreme southeastern part of the quadrangle, is a south-plunging syncline of relatively steep dips. Local undulations in the structure occur in several parts of the quadrangle, as indicated by the contours on Figure 1.

The subsurface structure is described under the discussion of individual oil and gas sands.

THE OIL AND GAS SANDS

List of the Oil and Gas Sands

Eight different sands are producing oil or gas or both oil and gas in this quadrangle. Those and other noteworthy sands are listed in Table 1. In this table and in the discussion of the sands to follow, the name most commonly applied to each sand by the operators in the area is used. In many of the well records, as received, especially the records of wells in isolated portions of the area, the sands were not correctly identified. It was necessary, therefore, to draw a series of detailed well-to-well correlation sections in various directions and positions across the quadrangle. Preliminary correlation sections have also been run from this quadrangle to the type areas of Oil Creek Valley, Pleasantville and Warren. The tentative correlations thus drawn are shown in Table 1.

Venango Oil Sand Group

At the Oil Creek type locality the Venango Oil Sand Group consists, in descending order, of the First, Second, Third Stray, and Third Venango oil sands. This group is a distinct stratigraphic unit which is overlain and underlain by shale. This unit is clearly recognizable eastward across the Tidioute quadrangle, where it includes the oil sands from the top of the First through the Fourth sands.

Isometric projection of Venango sands: To illustrate the relative positions, structure, and lateral variations of the sands of this important group, the isometric projection, Figure 2, was prepared. For this projection the quadrangle was divided into 81 small rectangles by equal-spaced north-south and east-west lines. Along each of these lines, hence on each side of each small rectangle, were drawn sections as

Table 1. SHALLOW OIL AND GAS SANDS OF TIDIOUTE QUADRANGLE

Name of sand	Average interval to Corry	Average thickness	Maximum thickness	Tentative correlations	Remarks
Corry		20	30		Blue Monday of well records. Not productive
First	250	20	45	First of Oil Creek	Sand lenses in First sand "formation".
"White"	295	15	50		Variously called Lytle, Second, First and Red Valley in well records. Outcrops at Trunkeyville
Second	340	20	30	True Lytle of Pleasantville type	Red Valley of Pleasantville and Oil City.
Salt	390	15	30	Type Venango Second of Oil Creek	
"Little Minister" Stray	440	15			Found only in southern part of quadrangle. General horizon of Gray sand of Church Run.
Third	490		120	Type Venango Third Stray of Oil Creek	Extremely variable, probably combined with Fourth for maximum thickness. Also called Black oil sand.
Fourth	530	10	37	Type Venango Third of Oil Creek	Also called Green oil sand.
First Warren	990		100	First Warren of Warren	A non-productive sandy zone.
Second Warren	1090		75	Second Warren of Warren	A sandy zone.
Queen	1210		120	Glade or Third Warren of Warren	A sandy zone with 10 to 15 feet or more of clean sand occurring locally in it.
Clarendon	1320		40	Clarendon of Warren	A sandy zone reputed non-productive.
Speechley	1420		105		A sandy zone locally containing 20 to 50 feet of productive sand.
Cooper	1620		55		

complete and accurate as the required scale and available data permitted. Individual wells not on section lines were projected to the nearest line. All strata above the First sand were omitted from the sections to avoid one section concealing another. An idea of the thickness of the omitted strata may be gained from the surface profiles on the north and west sides of the projection.

The individual sands of this group are discussed below in as much detail as their importance warrants and as the data and space permit. Maps showing the exact limits of areas now producing oil or gas and of those formerly productive but now abandoned were prepared for each sand. Where possible the areas in which drilling has shown oil or gas to be present but in which they have not been produced commercially are shown on these maps. In the discussion of sands these maps are referred to as the production maps.

First sand

The First sand here occurs as local lenses or layers of fine- to medium-grained white or gray sandstone in an irregular group of thin-bedded shaly sandstones and sandy shales. These shaly sandstones and sandy shales are designated First sand "formation" in the well records. The top of these sand lenses, as recognized in the well records, is usually about 260 feet below the top of the Corry sandstone and about 230 feet above the top of the Third sand, but neither the top nor the bottom of it is clearly defined throughout the quadrangle. The First sand formation" ranges from 35 to 75 feet thick, often within short distances. Variation in sand content rather than in the actual thickness of the "formation" probably accounts for most of this irregularity. The First sand lenses are 1 to 45 feet thick, usually occupy about the central portion of the "formation" but are somewhat variable in stratigraphic position.

The First sand "formation" outcrops in the valley of the Allegheny River from the north boundary of the quadrangle to about a mile south of West Hickory, where the regional dip carries it below river level. The top is 1230 feet above sea level, or about 130 feet above river level in the Dennis Run section at Tidioute. The "formation" is here about 30 feet thick. At most of the outcrops it is a very fine-grained thin-bedded sandstone. Plant fossils occur sparingly in it. The only known exposure of clean sand that probably would yield oil or gas if under cover is an outcrop of medium- to fine-grained sandstone in a bluff on the west side of the river one mile south of Tidioute. Well samples indicate that the productive First sand is of the character noted at this outcrop.

The First sand ranks first in oil production in this quadrangle. Although primarily an oil sand, it produces relatively large amounts of gas in several localities.

The initial production of recently drilled First sand oil wells varied from ½ barrel per day in the poorer areas to 4 or 5 barrels per day in better localities. Earlier in the history of these fields, initial productions as high as 30 barrels per day were reported. The settled production of the wells is a small fraction of a barrel per day. The largest yield is usually from the thickest lenses of clean sand but in some localities sand only 8 to 15 feet thick yields well. Repressuring with air, gas or a mixture of the two is practised on most of the leases producing from this sand. Most of the leases are using the conventional pump and jack method in lifting the oil, but two leases are successfully using the air lift. Typically, the First sand oil is yellow or straw-colored. A lease near Fagundus produced from this sand a yellow oil of 52° gravity which at one time was called Tiona oil and received a premium of 15¢ per barrel.

"White" sand.

The term "White" sand is here used to designate a sand member which lies about 295 feet below the top of the Corry sandstone. It is 45 feet below the average position of the top of the First sand "formation". It is a very persistent sand member over that part of the quadrangle outlined in Figure 3. Where this sand is absent its stratigraphic position is occupied by the sandy shales termed First sand "formation". It appears, therefore, that this sand is, stratigraphically, an extensive lens in, or forming the bottom of the First sand "formation", and that this "formation", the First sand and the "White" sand, form one general stratigraphic unit.

The "White" sand has been variously named by the drillers. In the only area here in which it is commercially productive (see Figure 1) it is called Second sand. Outside this productive area it is most commonly designated Lytle sand or, less frequently, "White" sand from the White farm between Fagundus and Neiltown, Red Valley sand, Second sand, or First sand. The names by which it is commonly called in different parts of the quadrangle are indicated on Figure 3. The name "White" sand is here used because it does not imply a correlation with any specific sand outside the quadrangle. The preliminary correlation sections westward to the Oil Creek valley indicate that it is not the First, Lytle or Second sand. It may later be found to correlate with the Red Valley sand at the type locality of that sand.

In thickness the "White" sand ranges from 1 to 50 feet, but is usually less than 30 feet. In the area where it yields commercial production the thickness ranges from 10 to 35 feet.

A thin ledge of sandstone at Tidioute probably represents the outcrop of this sand there. It is exposed as a massive medium-grained sandstone near river level at Trunkeyville, a mile south of which it dips below river level.

The "White" sand is of minor importance as an oil-producing horizon in this area. Where productive, a moderate quantity of gas occurs with oil. The initial production of recently drilled wells in the producing area has usually been less than 3 barrels per day, but initial productions up to 25 barrels per day were recorded earlier. The initial production seems to increase with the thickness of the sand more than in other Venango sands of the quadrangle. Repressuring is practised on some of the leases. Some of the abandoned leases (see Figure 1) are now flooded with fresh water and are thought to be flooding active leases to the southeast of them. Amber-colored oil is produced from the northern part of this area and dark-green oil from the southern part.

Second sand

The Second sand of this quadrangle is an irregular sandstone horizon, the top of which ordinarily lies about 340 feet below the Corry sandstone and about 150 feet above the Third sand.

Extent, character and thickness: Although it is very irregular in both thickness and character, the Second sand appears to be persistently present in most of the quadrangle. It outcrops along the Allegheny River from the northern boundary of the quadrangle to about half a mile north of Trunkeyville, where the general south regional dip carries it below river level.

Typically the Second sand is a medium- to fine-grained, gray sandstone. On the outcrop it varies irregularly from massive, non-shaly sandstone to thinly-bedded argillaceous sandstone with included layers of shale. Similar subsurface variations are indicated by the well records. Small pebbles are common in it both on the outcrop and in well samples. Although these pebbles are not confined to any particular part of the sand, and in places are irregularly scattered throughout its entire thickness, a thin pebble streak in the top of the sand is usually characteristic of it.

The thickness of this sand ranges up to 30 feet. Although there is little regularity in this variation, a general belt in which the sand is usually 15 to 30 feet thick, one in which it is less than 20 feet thick, and two in which it is absent, or present only as thin hard "shells", can be recognized. These thickness belts are represented in Figure 4.

Structure: The structure of the top of the Second sand in most of the quadrangle is represented by contours on the Second sand production map, Figure 5. This "structure" of the sand is the net result of the variations in the thickness of the sand, differential settling, folding of the strata and the general southward regional dip. The local irregular curving of the contours, the small "domes" and closed basins are primarily the results of variations in sand thickness. These local irregularities appear most prominent in the productive areas because only there can sufficient data be obtained to determine the structure in detail.

The most prominent fold in the quadrangle is the southwest-plunging Fagundus anticline. This anticline is more clearly defined in the Second sand than in the Corry sandstone at the surface. The west-plunging anticline in the eastern part of Triumph Streak oil pool is also more clearly defined and has steeper dips than the Corry.

Production: The Second sand is one of the principal oil-producing sands of the quadrangle, ranking second in importance. It contains very little gas, and has never been an important gas-producing sand here. The usual initial production of Second sand wells is about 2 barrels per day, but a few wells have had initial productions of 20 to 25 barrels per day. From these initial productions the wells decline, usually within a year or two, to an average settled production of about 1/5 of a barrel per day. Salt water is usually produced in small quantity with oil.

No direct correlation exists between initial production and thickness of the sand, except that where the sand is less than 10 feet thick the wells rarely, if ever, are commercially productive. Furthermore, as can be seen by a comparison of Figures 4 and 5, all the areas of present and past production lie in the belt where this sand is usually 15 to 30 feet thick. Drilling for Second sand production outside this belt is not recommended. Additional small producing wells probably can be obtained within this belt, especially between producing areas in the western part of it.

As can be seen from Figure 5, there is no consistent relation between the structure of this sand and the producing areas. The leases west of Fagundus are on the Fagundus anticline, and perhaps the oil accumulation there is a result of this fold. On the other hand, the more extensive leases northwest of Fagundus bear no apparent relation to the structure on the sand body. The initial production of the wells of this sand varies with the permeability and porosity of the sand much more than with its thickness or structure. A noteworthy fact is that Second sand production does not extend across the Triumph Streak pool. The structure there is anticlinal, and the sand is closely similar to that in Second sand pools, but the Second sand is non-productive over Third sand pools, except on the southern edge of the Streak.

Production from the Second sand is obtained entirely by pumping. Repressuring with air or gas or a mixture of the two is practiced on most of the leases now producing from this sand. The pressures range from 50 to 300 pounds per square inch, but 125 pounds is most commonly employed. Water flooding of the Second sand has not, as far as could be ascertained, been attempted in this quadrangle, and the opinion of most of the operators is that it would not be successful.

The Second sand oil is typically an amber color. Its specific gravity ranges from 44° to 48° Baume.

Salt Sand.

The term Salt sand is applied in the Tidioute quadrangle, and westward to Pleasantville, to a sandstone which lies about 50 feet below the top of the Second sand. It outcrops along Allegheny River from the northern boundary of the quadrangle to Tidioute, where the south dip carries it below river level.

The Salt sand, like the Second sand, is typically a fine-grained gray sandstone. It ranges from massive sandstone to shaly flagstone. Ripple marks and thin streaks of green shale are common in it. In thickness it averages about 15 feet and ranges up to 30 feet. Most of the well records show it to be fine-grained, hard, and white or gray.

As indicated on the production map, Figure 1, the Salt sand is a relatively unimportant producer in this quadrangle. Several wells found a "show" of oil or gas in it, others small amounts of salt water, but in most of the wells it is hard and "dry". A well one mile northwest of Fagundus, drilled about 1865 and now abandoned, is reported to have had an initial production of 80 barrels a day from the Salt sand, but many adjacent wells found it non-productive.

Oil was produced about 1868 to 1871 from the Salt sand in a small pool at Jamison on the west bank of the Allegheny River, near the southern boundary of the quadrangle, (see Figure 1). The wells declined rapidly from initial productions of

10 to 20 barrels a day, and are now abandoned. A small gas pool near Kellettville (see Figure 1) is the only area here in which the Salt sand is now commercially productive. The wells in this pool had initial productions of 31,000 to 290,000 cubic feet a day.

Correlations of Second and Salt Sands

Early in his work on the Venango oil sands Carll concluded that the Venango Second sand divides east of the type Oil Creek area into two sandstone members separated by shale (1). The Second sand of the Tidioute quadrangle is the upper of these two sandstones, called by Carll the B member of the Second sand (2). The Salt sand of this quadrangle is the lower or A member.

These sands have been traced in detail through the various leases of the Tidioute quadrangle, westward beyond the limits of the quadrangle to Pleasantville, and, in much less detail, from Pleasantville to the Oil Creek typo sections at Rouseville and Petroleum Center.

The Second and Salt sands of the Tidioute quadrangle are the Lytle and Salt sands at Pleasantville. These two sands apparently do not unite between Pleasantville and Oil Creek to form the true Venango Second sand, as Carll supposed. On the contrary, the preliminary sections there indicate that the Salt sand is the true Venango Second sand, and that the Tidioute Second sand, or true Lytle sand, grades into shale west of Pleasantville.

The Second sand of the Tidioute quadrangle is the upper member and the Salt sand is the lower member of the Salamanca conglomerate of New York.(3)

"Little Minister" Stray

In the southeastern part of the quadrangle a stray sand lies about 30 feet above the Third sand and 440 feet below the Corry sandstone. For convenience this sand is here called the "Little Minister" Stray from Little Minister Run where it is productive. (See production map Figure 1).

This is a fine-grained gray sandstone. Although its correlation outside the quadrangle has not been determined, it apparently occupies the general stratigraphic position of the Gray sand at Church Run, north of Titusville.

In the area where it formerly produced oil the wells had initial productions up to 10 barrels a day. The oil is high gravity and black.

Third Sand

Extent, character and thickness; The Third sand of this quadrangle is probably the Venango Third Stray sand of the type Oil Creek valley area, as was early recognized by Carll (4). It lies about 490 feet below the Corry sandstone. In most of the quadrangle it is less than 15 feet thick and is separated by 70 to 80 feet of shale from the Salt sand above and by 20 to 30 feet of shale from the Fourth sand below. In a few places, as in the Triumph Streak, and probably at Fagundus, the shale between the Third and Fourth sands is very thin or absent, and the combined sands are designated Third sand.

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1. Carll, J. F., Report of progress in the Venango County District: Second Penna. Geol. Survey, Report I., 1875, p.15

2. Carll, J. F., Geological Report on Warren County: Second Penna. Geol. Survey, Report I 4, 1883, p. 289

3. Cathcart, S. H., Structure and areal distribution of certain key beds in northwestern Pennsylvania, unpublished manuscript in Penna. Topo. and Geo. Survey files.

4. Carll, J.F., Report of progress in the Venango County District: Second Penna. Geol. Survey, Report I., 1875, p.30.

The general thickness distribution of the Third sand is indicated on Figure 6. In most of the eastern part of the quadrangle this sand is a thin, dense, fine-grained white or gray sandstone. It includes conglomerate lenses and layers in the western part of the area.

Structure: The attitude of the top of the Third sand is represented by contours on the production map, Figure 7. As in the Second sand, this "structure" is the net result of variation in sand thickness, folding and regional tilting.

The sharp anticlinal form of the top of the sand in the eastern part of the Triumph Streak oil pool is the result of thickening of the sand toward the center of the Streak. Except for regional tilting and downward scouring, the bottom of the sand here is essentially horizontal. Accordingly this "anticline" should not be expected to carry to deeper sands. It does extend upward, with diminishing intensity, through the Second sand (see Figure 5) and the Corry (see Figure 1) because of the compaction of the shales around this thick sand lens.

The southwest-plunging Fagundus anticline is clearly defined in the Third sand. Its flanks are steeper than those in the upper beds and it can be followed with little difficulty from the river east of Tidioute to the western boundary of the quadrangle. It does not conform to variations in the thickness of the sand and may be expected to continue downward with gradually increasing intensity.

A fairly distinct southwest-plunging anticline can be followed from a point about a mile east of Queen southwest to about a mile south of West Hickory.

Production: The Third sand is the most important source of oil and has produced considerable quantities of gas. The oil is black or very dark green and the sand is called the Black oil sand in some areas. It carries salt water.

Triumph Streak Oil Pool: Triumph Streak is the most important oil pool in the quadrangle. It is about 8 miles long and 600 to 1800 feet wide (see Figure 7), and extends from south of Tidioute westward beyond the limits of this quadrangle. Discovered in 1860, the year after the famous Drake well at Titusville, it has had two periods of development. The first period extended from 1860 to 1874. During the early stage of this first period the practise was to drill only into the upper part of the sand. The initial production of these wells ranged from 10 to 500 barrels per day. Some of the wells yielded only gas. A 500-barrel well was drilled on the island at Tidioute. Other wells were drilled on rafts in the river and had to be reclaimed after each flood. Later in this first period, as casing came into use and the total thickness of the sand was drilled, wells with reported initial productions up to 1,000 barrels per day were obtained. During the latter part of this first period water entering the sand through leaky casing and unplugged abandoned wells was flooding the field and by 1874 it was being abandoned. Gradually the water spread until practically the entire pool was flooded and abandoned. The second period of development started in 1898 and was characterized by dewatering of the flooded sand. Persistent pumping of the flood water reclaimed most of the old abandoned acreage. When dewatered, the average wells produced 10 to 18 barrels per day. The average present production of Triumph Streak wells is said to be .13 barrel per day.

The sand of Triumph Streak is a conglomerate consisting predominately of white quartz pebbles 2 to 3 millimeters in diameter in which occur discoidal pebbles 1 to 2 centimeters in diamater. These larger pebbles occur most abundantly in the eastern part of the pool where the sand is thickest.

The sand ranges from about 20 to 120 feet thick. In the western two miles of the pool in this quadrangle the sand is 40 to 60 feet thick. It thickens eastward to a maximum of 120 feet about half a mile west of the river. This eastward thickening is by addition at both the top and bottom of the sand, but most of it occurs in the bottom, apparently filling a scour channel. East of the river the sand thins rapidly to about 40 feet south of Tidioute. The sand is thicker through the center of the Streak than near the edges. From a maximum central thickness it thins gradually to the north and more rapidly to the south. At the south, and less noticeably so at the north edge of the Streak, it thins very abruptly and apparently divides into two sand members separated by shale. These two sand members are the Third and Fourth sands of the quadrangle. They are very poorly developed south of the Streak except in the area east of the river shown on Figure 7 where the upper member is 10 to 20 feet thick and productive. This upper member is absent, or present only as a thin "shell", between Triumph Streak and Fagundus.

Neither water flooding nor repressuring is practised in Triumph Streak. Gas cycling is the customary production practise in most of the pool. In this method the oil is produced under a vacuum and the gas removed and returned to the sand through intake wells. The oil is green, in places very dark green.

Its shallow depth at and near the river suggests that the sand may be commercially mineable. In places the sand is only about 130 feet below the surface. An 8 foot by 12 foot shaft was dug through the sand in 1864 south of the river near Tidioute. The top of the sand which was 5 feet thick, was encountered at 152 feet. A plan to run drifts in the sand was not carried out (1).

Fagundus: The Fagundus pool (see Figure 7) lies about three miles south of Triumph Streak. It is roughly circular, covers about 1,200 acres, and has produced oil continuously since its discovery in 1870.

The Third sand, which is the producing horizon, is 30 to 40 feet thick in the central part of the pool and thins outward from the center. It is predominantly a medium-coarse gray sandstone, but includes pebble layers, especially at the top and bottom. Shale and hard non-productive sand occur irregularly in it.

This pool lies on the gentle southwest-plunging Fagundus anticline, which may have an important influence in the accumulation of the oil. The producing area is controlled directly by sand conditions, however. The sand becomes thin, hard and non-productive at the outer edge of the pool. Repressuring with gas and air is practised successfully in about half of the active leases. The oil is very dark green.

Other Third Sand Pools: Several other areas producing or formerly productive from the Third sand are indicated on Figure 7. Particularly noteworthy among these are the five pools in the southern part of the quadrangle, south and southwest of West Hickory. The sand in these pools is 35 to 55 feet thick, and may represent the combined Third and Fourth sands, as in the Triumph Streak. The northwest trend and alignment of the pools suggests that they may be parts of a more continuous, but undeveloped, productive area. Drilling has been done between some of the pools, especially between the easternmost two, but not enough to prove that the areas between these pools will not be productive.

Extending from West Hickory northward for two miles is the Trunkeyville-West Hickory Pool. Production here started at West Hickory in 1870. The sand is coarse to pebbly in texture and very irregular. As at Fagundus the productive area is limited to the thicker, coarser sand. The oil is black.

The Heart's Content pool, eight miles east of Tidioute, is the easternmost producing area of the quadrangle, and is widely separated from the other Venango oil sand pools. The sand here is a coarse, pebbly sandstone 5 to 7 feet thick.

Fourth Sand

Except where combined with the Third sand, as in the Triumph Streak, the Fourth sand of this quadrangle lies 30 to 40 feet below the top of the Third sand, or at an average interval of about 530 feet below the Corry sandstone. In the eastern half of the quadrangle it is not reported in the well records and apparently is absent, or present only as thin shaly sandstone. Although it is reported in several scattered areas in the western half of the quadrangle, the Fourth sand is persistently present only in the southwestern part, west of the river, where it is called the Green oil sand, in contrast to the Black oil sand, the Third. Where present it is typically about 10 feet thick. The maximum recorded thickness is 37 feet.

The Fourth sand here probably correlates with the Venango Third sand of the Oil Creek type area, as early recognized by Carll (2). Except where combined with

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1. For exact location of this shaft see Figure 8 of this report. For further details concerning it see Carll, J.F., Geological Report on Warren County; Second Penna. Geol. Survey, Report I 4, 1883, pp. 344-345

2. Carll, J. F., Report of progress in the Venango County District: Second Penna. Geol. Survey, Report I, 1875, p.30

the Third sand, the Fourth sand is a very minor source of oil and gas. There are four producing gas pools, one abandoned gas pool, one producing and one abandoned oil pool in this sand. All of these pools are small and lie north and west of the river. (See Figure 1).

Sands Below the Venango Oil Sand Group

At an average distance of about 90 feet below the Fourth sand lies the top of a brown or purplish shale, called "pink rock" in the well records. This "pink rock" is about 325 to 350 feet thick and contains local layers of darker shale and a few thin "shelly" sandstone layers.

First Warren Sand

At or near the bottom of the "pink rock" lies an irregular zone of shaly sandstone called the First Warren sand in well records. Its top is about 900 feet below the Corry sandstone. This sand is recorded only in the northern half of the quadrangle. Its reported thickness ranges from 5 to 100 feet. In a few of the wells a "show" of oil or gas is reported in this sand, but it has never been commercially productive in this quadrangle.

Second Warren Sand

The Second Warren sand is here an irregular shaly sandstone similar to the First Warren. Its top lies about 1090 feet below the Corry sandstone. Its reported thickness ranges from 5 to 75 feet. A few wells in the northern half of the quadrangle report "shows" of oil or gas in this sand. Oil and gas in small quantities are being produced from it in a pool two miles east of Tidioute (see Figure 1). This small pool is now undergoing further development.

Queen Sand

The Queen sand is a white, coarse to pebbly sandstone about 1260 feet below the top of the Corry sandstone and 770 feet below the Third sand. It is 1 to 15 feet thick. In some well records it is reported to be as much as 75 feet thick, but associated shale and shaly sandstone doubtless are included as sand.

The Queen sand occurs as a series of lenses at the bottom or in the lower portion of a dark sandy shale or shaly sandstone. This shale and shaly sandstone, called Queen sand "formation" in well records, are 100 to 120 feet thick. Although quite irregular, this "formation" with its lenses of white sand forms a distinct stratigraphic unit which is persistent and readily recognized in most of the quadrangle. It occupies the stratigraphic position of the Glade sand at Warren. The structure of the Queen sand is represented by contours on the bottom of the sand in Figure 8. The bottom of the sand was chosen for contouring because its position is more clearly recognizable in the well records. The most persistent structural feature in this sand is the Fagundus anticline. It is noteworthy that this fold has increased in intensity and that its crest has migrated to the southeast from its position in shallower sands.

The Queen sand is the main gas-producing sand of the quadrangle, and ranks about fourth as an oil producer. The areas in which this production occurs are indicated in Figure 8. Oil occurs in small amounts in several localities but the commercial oil production has been derived almost entirely from the Red House pool.

The Red House pool, or Queen sand oil pool as it is sometimes called, was prolific but short-lived. The discovery well, completed in April 1922, had an initial flow of 120 barrels per day and a rock pressure of 700 pounds per square inch. The "pay" sand in the pool is 4 to 15 feet thick and the initial production of the early wells varies directly as the sand thickens. As shown on the Queen sand production map, Figure 8, the pool is U-shaped. On the southeast side of this U, which was the very best part of the pool, the wells had initial productions of 50 to 700 barrels a day and averages about 100 barrels per day, for the first week. At the southwest end in the northwest half of the U the sand is thinner and was less productive. In the non-productive strip inside the U the sand is thin and of very low porosity.

Structurally the Red House pool is on the southwest-plunging Fagundus anticline, the unproductive streak in the central part of the pool corresponding with a low area in the fold. This structure may have influenced the accumulation of the oil here, or, if the fold was present as a shallow area on the sea bottom when the Queen "formation" was being deposited, it may have influenced the character (mud content) of the sand.

Although exact figures are not available, the original gas-oil ratio evidently was high in the Red House pool. The thin, coarse character of the sand and the depletion of the gas energy resulted in rapid decline of the wells. The pool reached a peak production of about 1,500 barrels natural flow per day about six months after its discovery (1). Except for a few leases, one of which is repressuring, the pool is now abandoned. It is reported that the saturation is too low in most of the pool for commercial secondary-recovery operations. There is very little salt water in the sand.

A small gas pool east of the oil pool had wells with initial gas production up to 10,000,000 cubic feet per day.

The Queen gas pool (see Figure 8) was discovered about 1888. Most of the gas production here is obtained from the thick shaly type of sand known to drillers as Queen sand "formation". That this type of sand seems to be more suitable for gas accumulation and production than for oil probably is the result of its low permeability, as was suggested by Torrey (2). Locally in this gas pool the sand is less shaly and there contains a small quantity of oil. The best part of the pool was near the town of Queen where wells with initial productions up to 5,000,000 cubic feet were drilled. Many of the wells are still producing. This part of the pool is also structurally the highest, both by its location on the regional dip and on a gentle anticline (see Figure 8). This anticline is the fold which can be traced in the Third sand southwest to West Hickory.

Wells to this sand in the areas shown in Figure 8 as potentially productive probably would yield 2,000 to 5,000 cubic feet per day. No large undeveloped Queen sand pool is probable in this quadrangle. Many wells have been drilled outside producing areas. The locations of several of these wells are shown in Figure 8. West of the river the sand is present locally but thus far non-productive.

Clarendon Sand.

As noted in the selected well records in this report, a few wells record a sand about midway between the Queen and Speechley sands. As reported, this sand is up to 40 feet thick and lies about 1,320 feet below the Corry sand. It occupies about the stratigraphic position of the Clarendon sand at Warren, and is so designated in the records. Two wells (see table of selected well records) report a show of gas in this sand. It has not been commercially productive here.

Speechley Sand.

The Speechley sand lies at an average interval of 930 feet below the top of the Third sand or 1,420 feet below the Corry sandstone. Where typically developed it is a gray to chocolate-colored, fine- to medium-grained sandstone 70 to 105 feet thick. Elsewhere it may be a thin shaly sandstone. As a result of this irregularity its reported thickness ranges from 4 to 105 feet.

This sand has been correlated with the true Speechley sand by a section run from this quadrangle southwestward about 10 miles to the original type Speechley well near Coal Hill in Pine Grove Township, Venango County. According to a correlation section run across the southern part of the quadrangle and on eastward about

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1. Johnson, M.E., Tidioute Oil Pool, Warren County, Penna.: Penna. Topo. and Geol. Survey, Bull. No.79, 1923, p.16.

2. Torrey, Paul, Origin, migration and accumulation of petroleum and natural gas in Pennsylvania: Amer. Asso. of Petrol. Geol. Symposium on Problems of Petroleum Geology, 1934, pp. 474-479

three miles to the original Balltown pool, this sand, or at least the upper part of it, occupies the stratigraphic position of the Balltown sand. In the southern part of this quadrangle the terms Balltown and Speechley are used rather indiscriminately to designate this sand. The correlation is recognized in some of the records which call the sand the Balltown-Speechley. In several of the wells, especially in the southwestern part of the quadrangle, shale 1 to 5 feet thick occurs in the middle of the sand. Where this shale is recognized the upper 30 to 40 feet of sand is described as gray and called Balltown, and the lower 30 to 40 feet of chocolate-colored sand is called Speechley. As such thin shale breaks are not persistent the entire sand body is here called Speechley and correlated with the Balltown; also it correlates with type Speechley.

The Speechley is a minor oil- and gas-producing sand in this area. The gas production occurs only in the southwestern part of the quadrangle where two small pools have been developed (see Figure 1). The average initial production of the wells was 40,000 to 50,000 cubic feet per day. As nearly as could be determined this production was obtained from the lower part of the sand, below the shale mentioned above. A few other wells near but outside those pools got small amounts of gas in the sand.

Oil in small quantity has been obtained from the sand in a few scattered areas in the southeastern part of the quadrangle (see Figure 1). A few other wells in this part of the area got "shows" of oil in this sand. This part of the quadrangle is close to the Balltown pool, and most of the wells here record the sand as Balltown.

Sands below the Speechley.

Records were collected of about 35 wells in this quadrangle that go 100 feet or more below the Speechley sand. All except a few of these report one or more deeper sands, but the sands appear at irregular stratigraphic positions. Two of the deeper sands are particularly persistent, however, and warrant some consideration.

The upper sand is 5 to 55 feet thick and about 200 feet below the top of the Speechley or about 1,620 feet below the Corry sandstone. It occupies the general stratigraphic position of the Cooper sands, and is so called in many of the records. It is not productive and none of the records report "shows" of oil or gas in it.

The lower of the two more persistent sands is 2 to 22 feet thick and about 340 feet below the Speechley or 1,760 feet below the Corry sandstone. It is not productive and none of the records report "shows" of oil or gas in it.

Several deeper sands are reported in some of the wells and are listed under "miscellaneous" sands in the table of well records. Among the upper of these miscellaneous sands is probably the western equivalent of the Bradford Third sand but definite correlation must await further data east of this quadrangle. One well in the southern part of the quadrangle (No.166 in the list of well records) got a good "show" of oil in a dark sand about 2,800 feet below the Corry sandstone.

One well in the quadrangle was drilled through the Oriskany and Medina sands. This well, the Ulf No.1, on the bluff overlooking Tidioute, encountered small quantities of salt water in about 15 feet of Oriskany sandstone at a depth of 4,334 feet, produced 15,000 cubic feet of gas per day from the red Medina at 5,615 and 100,000 cubic feet from the white Medina at 5,757 feet. The record of the upper sands in this well is given in Table II. The complete record has been published by Fettke(1).

Selected Well Records.

Of the 2,500 well records collected, 181 are published below. These records were carefully selected as the most complete and representative of the sands. The locations of the wells whose records are here published are shown in Figure 8. This map also shows by conventional symbols the location and drilling results of the wells outside producing areas and not covered elsewhere in this report.

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1. Fettke, C. R., Subsurface Devonian and Silurian sections across northern Pennsylvania and southern New York: Bull. Geol. Soc. Amer., vol. 44, 1933, pp. 604-605.

No sand.
Sand known to be present
Recorded as shell or shells
Show of oil.
Show of gas.
Salt water
Mountain sand.
A little good [illegible] sand with gas at base
Eighty-foot sand.

1 well drilled through Fourth sand, all sands poor.
Red rock.
Slate rock.
Sandy from bottom of First through Second.
Dark sand and salt water
Good dark sand or [illegible] or shell, with show of oil.
"Little Dunkard" stray sand.
Drilled through Bedford.
Through Fourth sand

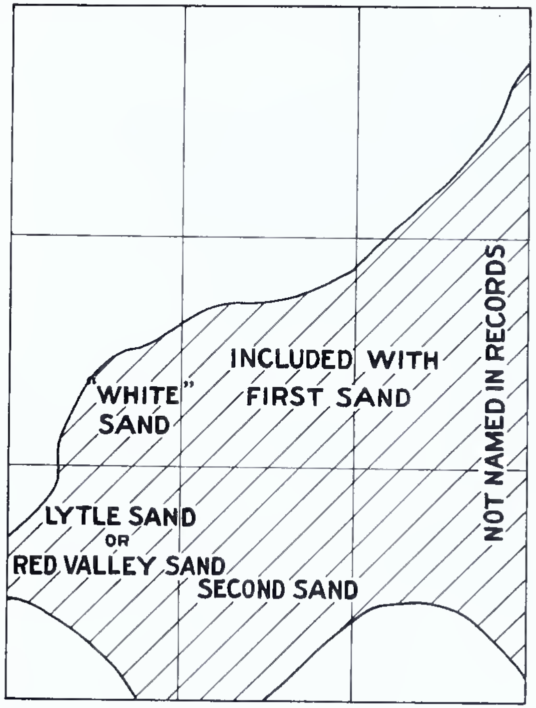


Fig 3 MAP SHOWING AREAS (SHADED) IN WHICH "WHITE" SAND OCCURS EITHER ALONE OR AS A PART OF THE FIRST SAND, AND THE NAMES BY WHICH IT IS KNOWN.

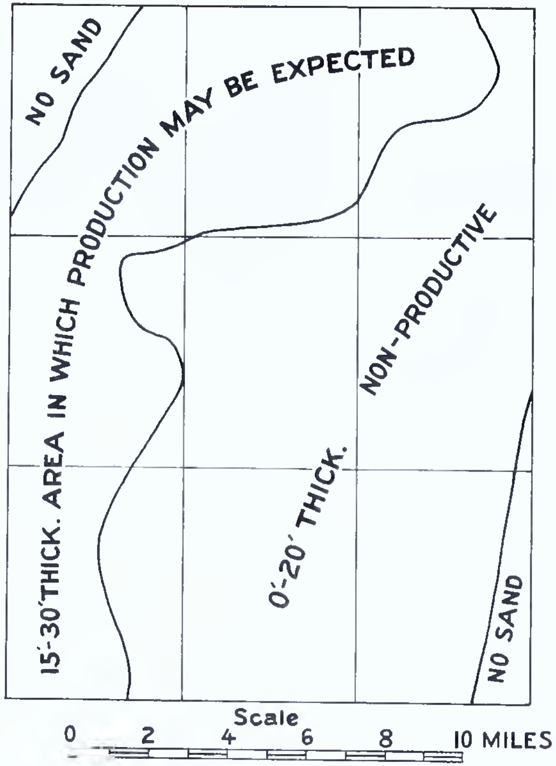


Fig 4 MAP SHOWING THICKNESS OF SECOND SAND.

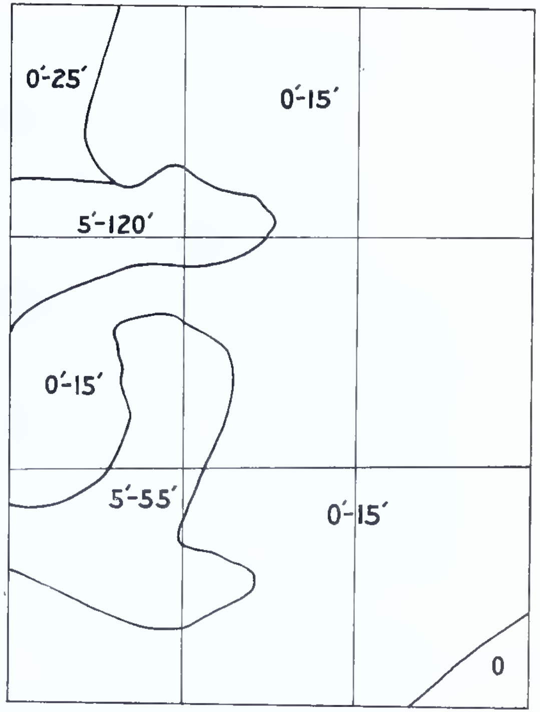
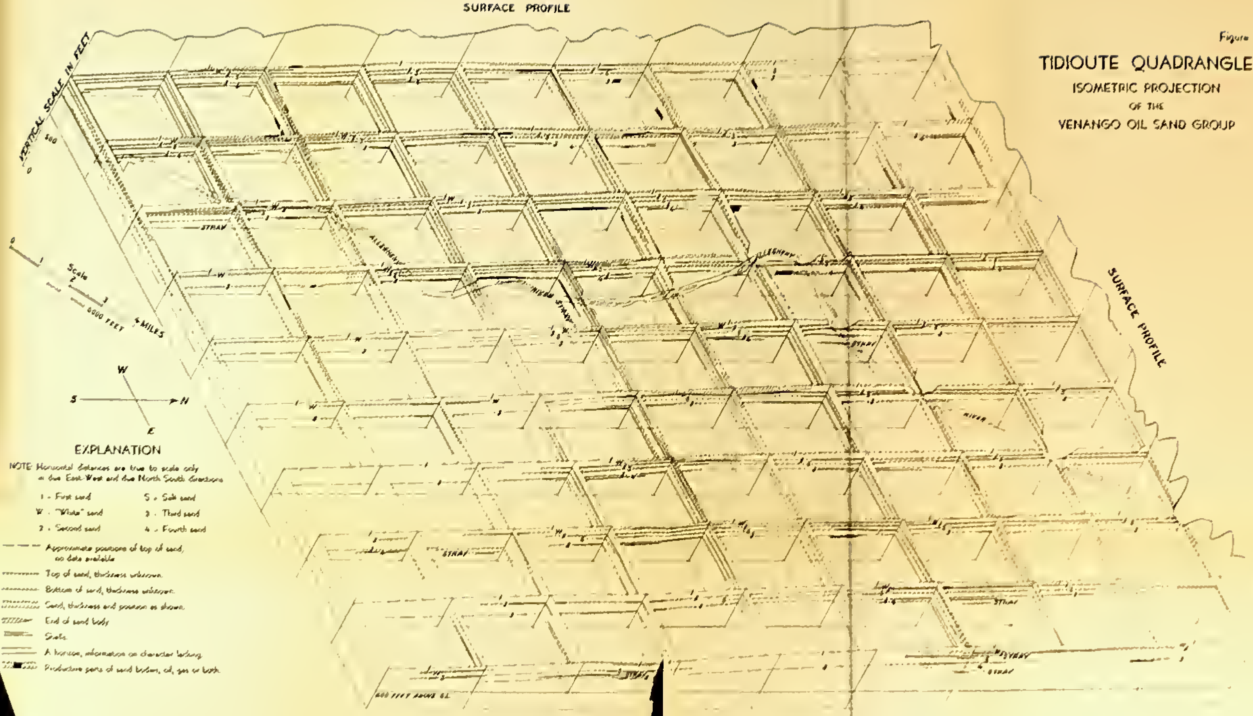


Fig 6 MAP SHOWING THICKNESS OF THIRD SAND

Figure 2

TIDIOUTE QUADRANGLE

ISOMETRIC PROJECTION
OF THE
VENANGO OIL SAND GROUP

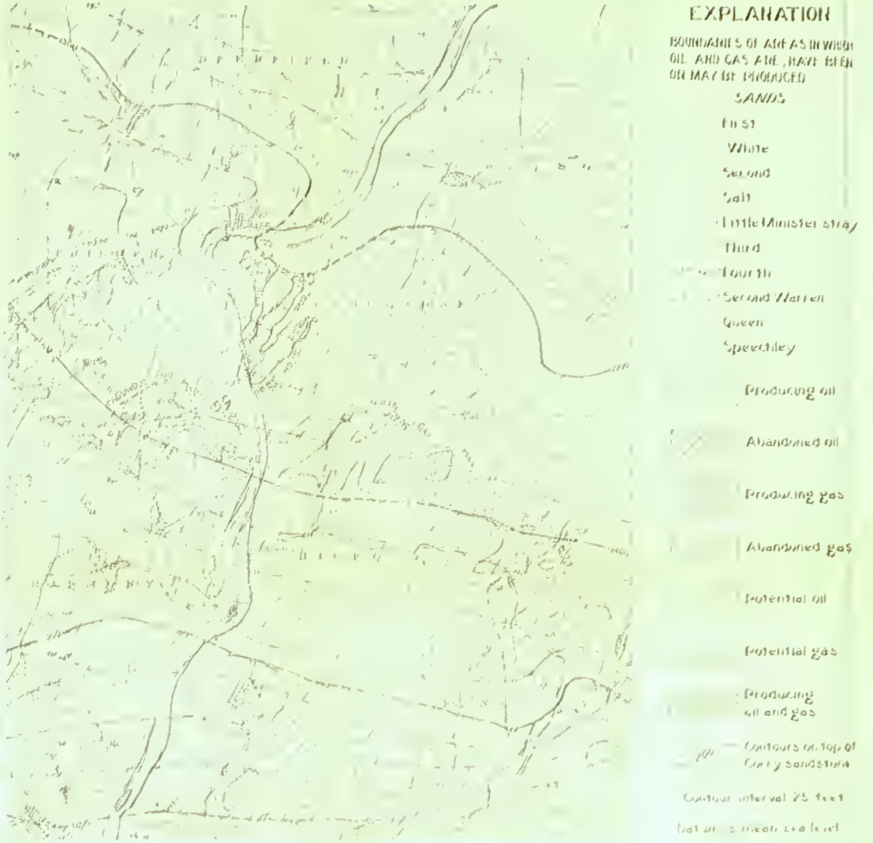


EXPLANATION

NOTE: Horizontal distances are true to scale only in due East-West and due North-South directions

1 = First sand
W = "White" sand
2 = Second sand
S = Salt sand
3 = Third sand
4 = Fourth sand

- - - Approximate position of top of sand, no data available
Top of sand, thickness unknown
Bottom of sand, thickness unknown
Sand, thickness and position as shown
End of sand body
Shale
A horizon, information on character lacking
Productive parts of sand bodies, oil, gas or both


EXPLANATION
BOUNDARIES OF AREAS IN WHICH OIL AND GAS ARE, HAVE BEEN OR MAY BE PRODUCED
SANDS
First
White
Second
Salt
Little Minister stray
Third
Fourth
Second Warren
Queen
Speechley
Producing oil
Abandoned oil
Producing gas
Abandoned gas
Potential oil
Potential gas
Producing oil and gas
200
Contours on top of Corry sandstone
Contour interval 25 feet
Datum is mean sea level

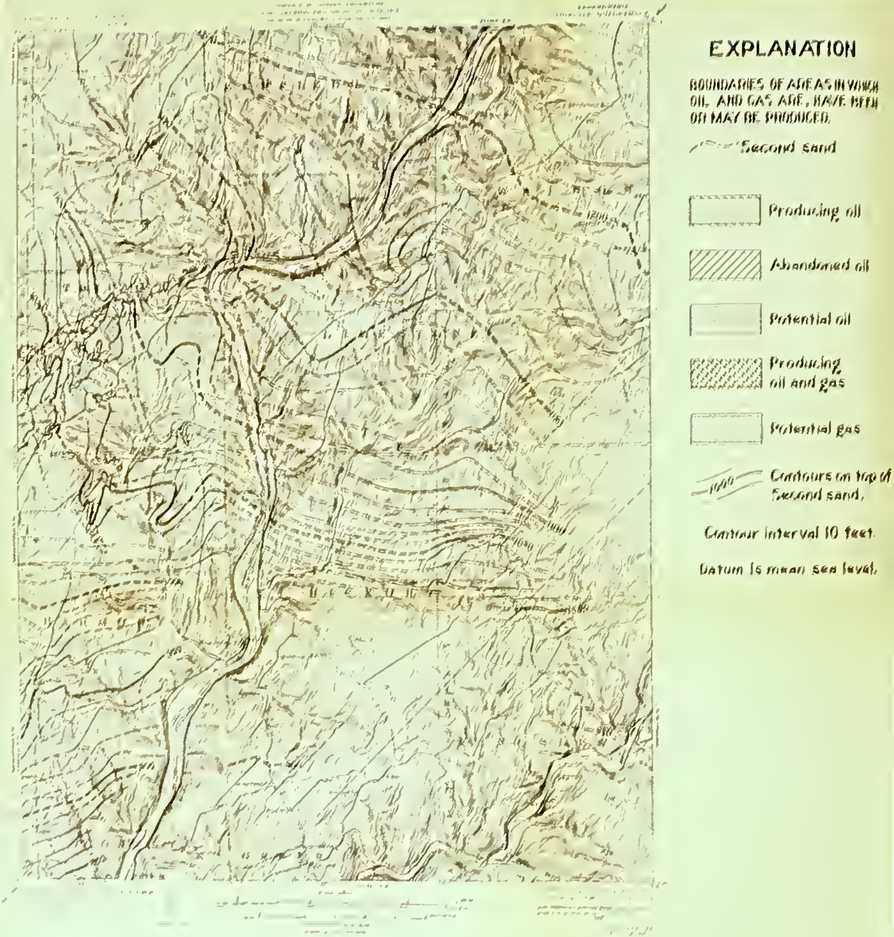
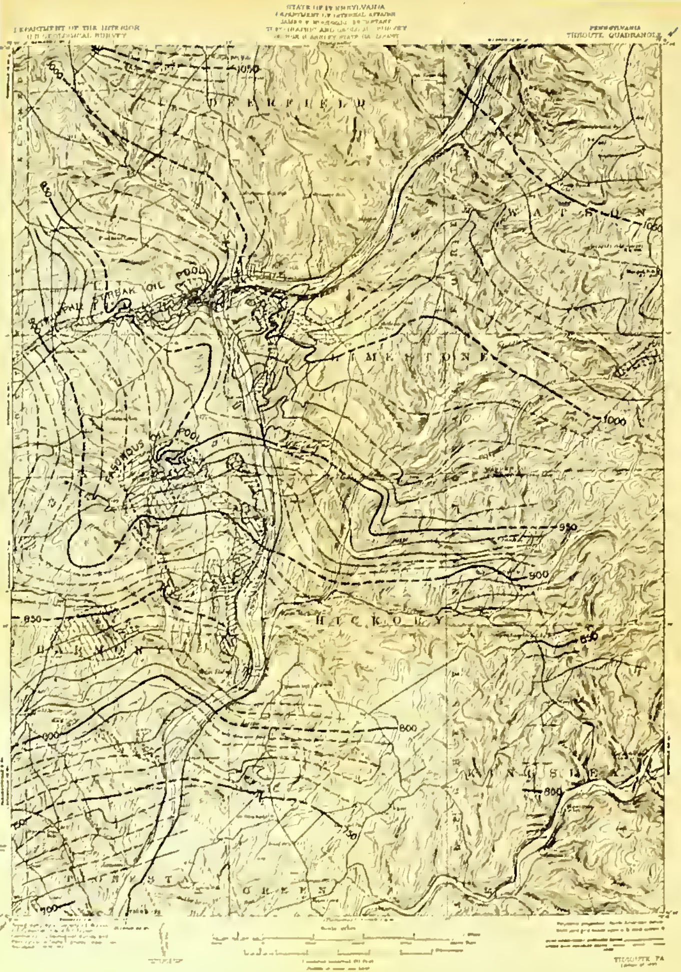


Figure 5. Map showing Second sand production and structure.



EXPLANATION

BOUNDARIES OF AREAS IN WHICH OIL AND GAS ARE, HAVE BEEN OR MAY BE PRODUCED.

- - - Third sand

▨ Producing oil

▨ Abandoned oil

☰ Potential oil

░ Potential gas

1000 Contours on top of Third sand.

Contour interval 10 feet

Datum is mean sea level.

Figure 7. Map showing Third sand production and structure.

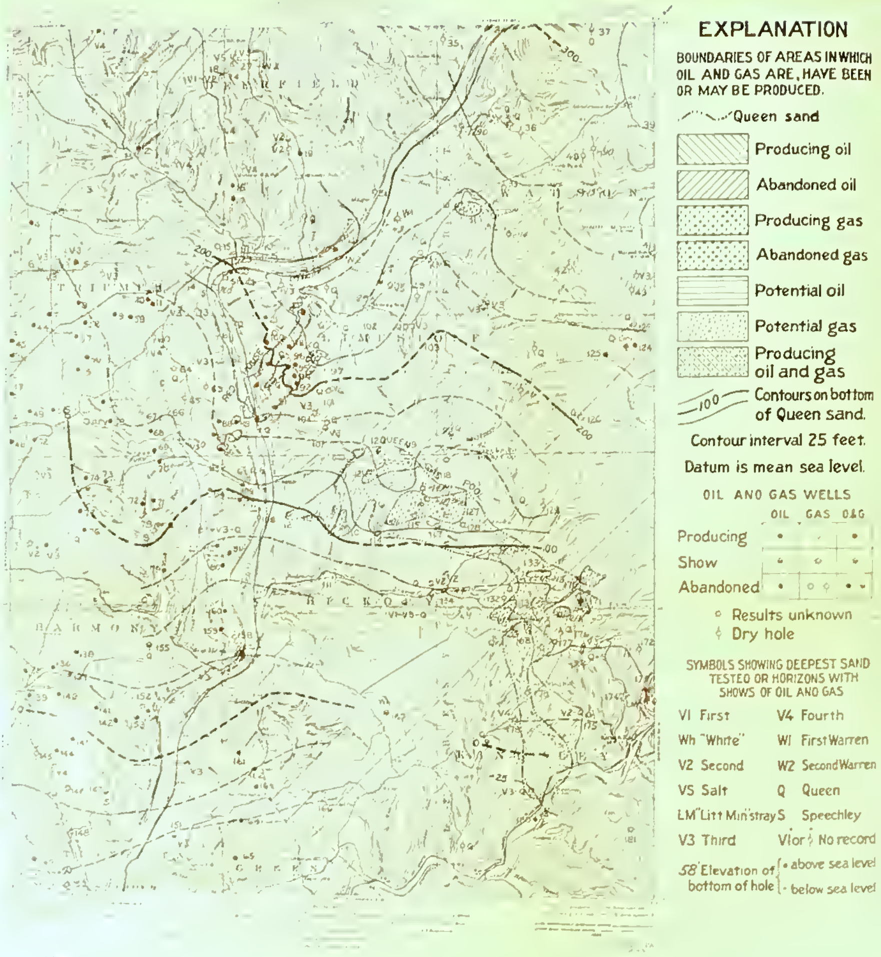


Figure 8. Map showing Queen sand production and structure and location of wells, the records of which are published in this report.